The Evolution of Radiology from Paraclinical to Clinical

Hong Khim Boey,[1] *DMRD, FAMS, FRCR*

Abstract

The perception of Radiology in the early 60s as paraclinical stems from the poor image the clinicians had for our limited resources in providing only plain film studies, VIPs and the single contrast barium studies which exclude only gross lesions. The evolution to clinical status started as early as the mid 60s. My personal recollection and reflection of the histological events that took place covered here highlights the reasons for the transformation from paraclinical to clinical and these form the main theme for this paper. Radiologists' professionalism plays an infinite part in the evolution to clinical Radiology. Rapid technological advances in imaging help to propel Radiology to the forefront. But credit must go to the individual Radiologist for their personal efforts and contributions. Reflection on past events of Radiology in Singapore leading to the establishment of Clinical Radiology was presented. The future of Radiology is brought up for discussion on the role of Radiologists with reference to subspecialisation necessitated by the ever increasing advances in Medical Imaging and demand for Interventional Radiology.

Ann Acad Med Singapore 20009;38:653-9

Key words: Reflection and recollection, Paraclinical to clinical, Technological advances, Specialisation and sub-specialisations

Friends and Colleagues

I would like to thank the Academy of Medicine and the Singapore Radiological Society for giving me the honour of delivering this year's F Y Khoo's Memorial Lecture.

I believe that I am one of the few radiologists in Singapore who had the privilege of working with Dr F Y Khoo when I joined the Department of Radiology in 1964 at Dr Chow Khuen Wai's prompting.

Dr Khoo headed the department of two disciplines diagnostic and radiotherapy, practising both as a therapeutic as well as diagnostic radiologist.

Dr FY Khoo reading a chest X-ray.

Dr F Y Khoo who inherited the department from the British radiologist Dr Young, after the Japanese war, was a man of principles and had run the radiology department at SGH with a firm hand, but with strong encouragement allowing for the development of modern radiology in Singapore.

I continued to keep in touch with Dr Khoo until his final years as I was living near him and used to meet him and his wife at the Tanglin Club.

In 1966 when I returned from training at the Hammersmith Hospital in London an independent department of diagnostic radiology was created with Dr Chow as the head.

Historical Events

Today's talk is on my personal reflection of radiology in Singapore from the early 60s to its present time, with emphasis on the Transition of Radiology from paraclinical to clinical.

Dr Khoo far right; Dr K W Chow second from right.

[1] Department of Diagnostic Radiology, Singapore General Hospital, Singapore.
Address for Correspondence: Dr Boey Hong Khim, Department of Diagnostic Radiology, Singapore General Hospital, Outram Road, Singapore 169608.

I will first begin by discussing on the historical events leading to the modernisation of Radiology in Singapore. This started in Singapore General Hospital as early as in 1966 upon my return from my training in the UK.

After my DMRD course in 1966, I did a Neuroradiology fellowship in Queen square's Neurorado-logical Centre in London, with attachment to a renowned radiologist in vascular interventional procedures which led me to kick start Interventional Radiology in Singapore with a successful lower limb catheter dilatation of a narrowed femoral artery when I returned to Singapore.

Earlier, Dr Khoo started the mammogram with an over couch X-ray beam, with him and Dr Chia Kim Boon as the principal persons in doing the mammogram and diagnostic evaluation. Before the introduction of double-contrast barium studies in 1978, single contrast BMX was carried out with radiologists having to undergo dark adaptation before each examination.

Dr H K Boey performing a barium meal in the dark.

Endoscopy was taught by a radiologist as part of the curriculum in the postgraduate medical course for surgeons and physicians from 1978 to 1981.

Dr Toh Chin Chye introduced to Endoscopes by Dr Boey.

Ultrasound investigation began with a simple transcranial scanning for midline shift some time in 1968, a technique learnt from Queensquare Neurological Centre, London, UK.

I remember the department was unable to purchase an ultrasound machine and the first machine was donated by a patient of Dr Siva from Toa Payoh Hospital sometime in the early 1970. Dr Siva generously assigned the ultrasound machine to the Diagnostic Radiology.

In 1970 the first Cardiovascular Lab for cardiac catheterisation and coronary angiogram was established at the Outram Road General Hospital.

For sometime, the catheters had to be fashioned for the different angiogram procedures. Perhaps this may have initiated the superselective angiogram which took off in a big way in 1978 after my return from Japan upon acquiring the skills from Dr Joe Ariyama.

Subsequently, superselective angiogram of the vertebral, carotid arteries, coeliac axis, superior mesenteric and inferior mesenteric arteries, including the pelvic vessels became a standard practice.

The first CT scan in Singapore was installed in 1969 in the Tan Tock Seng Hospital and this was a Rotate and Translate CT head scanner in 1969.

The region's first MRI was installed in a private clinic in 1986 with GE's first clinical 0.5 Tesla machine.

Mr Yeoh Cheow Tong, Minister of Health opening the MRI Center. Receptionists of the MRI Center on the right.

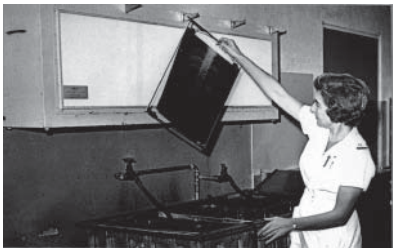
This became a training centre for overseas radiologists who came from Indonesia, Hong Kong, and Taiwan, including our own institutional radiologists.

Functional MRI was first installed in the MRI machine in TTSH's Advance Imaging Centre in 1995, upgrading our imaging position in Neuroradiology.

In the same year, the Ministry of Health approved the setting up of a separate Department of Neuroradiology after many years of consideration.

Neuroradiologists at TTSH: Dr H K Boey on the right, and on the extreme left, Dr Francis Hui.

Change in plain film processing to the present day daylight cassette loading system.



Wet film processing from DDR film archive.

Plain film X-rays were physically processed in a dark room, first by hand and later by automatic processors and this went on for a long time until about the early 1990s when daylight loading cassettes were introduced in TTSH and SGH.

Dr Boey interpreting a barium enema studies.

We have now gone from plain film processing to the modern day computerised PACS system for X-ray viewing.

Use of the PAC system for X-ray reading.

Teleconferencing took place in the early 1990s using telephone line, with discussion between foreign experts from Philadelphia and Stanford University on the interpretation of interesting cases in clinical practice.

TeleRadiology came about only lately, although it took place in UCSF and Philadelphia in the early 90s.

The Transition of Radiology from Paramedical to Clinical

In the second half of the 20th century, Radiology has become an essential integral part of modern medical practice.

Prior to 1960, Radiology did not have an important role in Medicine and was regarded as paraclinical.

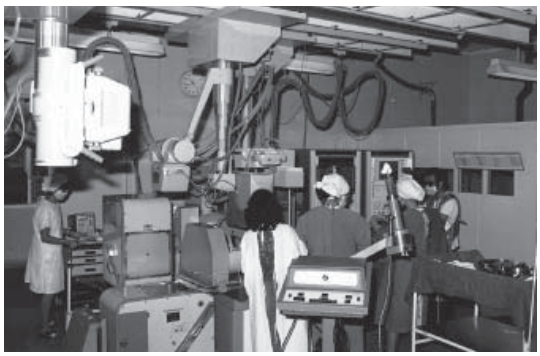
Even senior posts for our young radiologists were not available. I remember the department had to borrow a registrar post when it came to my turn for promotion.

The transition begun in 1963 with the modernisation which started with Dr Chow's special interest in Vascular Radiology when he introduced the Seldinger method of arterial puncture.

Vascular Radiology represents the hallmark of radiology and this led to lymphangiogram, Cardiac catheterisation, Aortogram and Angiogram and later Cannulisation of blood vessels for interventional work.

CV Radiology was established in 1970 with the help of Aubrey Pit from Australia.

This practically revolutionised the diagnosis and treatment of heart disease so much so that the Department faced intense lobbying for its transfer to CV specialty and had it not been for Dr Chow's administrative skill and special interest, Radiology would have lost an important binding factor.



The first Cardiovascular Laboratory in SGH.

Dr Chow fought off the numerous attempts with superb management including getting Radiologists to train Cardiologists, made the MOH to see the advantage of retaining the lab and services within the X-ray Department.

Radiology's importance in medical practice rapidly grew because of individual Radiologist's interest in the art and perhaps it was due to good fortune that the Department had several skilful Radiologists to enhance and continue with the growth.

Anterior approach with a long needle for the guide wires in angiography was introduced independently here in the mid-1970s and this reduced the incidence of haematomas at the punctured site considerably.

In earlier practice, the use of catheters was a big challenge. Selective canalisation of vessels became an art with

the fashioning of catheters necessary for superselective canalisation of vessels for interventional work.

Radiologists with skilful hands were much sought after, with the increase demand for diagnostic angiograms or interventional procedures.

Demonstrations of small lesions in the liver were made possible and the treatment of malignant lesions becomes a great challenge at the beginning of the mid-70s. with superselative angiography. Fine needle aspiration biopsy with Chiba needles started in 1979 with needles brought back here from Japan, further enhanced the standing of radiology in medicine.

In the mid-70s when interventional radiology came into practice, this was not without any resistance from the vascular surgeons.

Good PR with our surgical colleagues paid off and interventional radiology took off in a big way, and helped by the provision of endoscopy; and with the double contrast barium studies of the GI tracts, radiologists were eventually accorded admitting beds in the wards by the early 90s.

The co-operations between the clinicians, surgeons and the radiology department were never better in the history of radiology. The team work spirit enhanced patient care and history was in the making.

The early detection of cancer in the stomach and colon and the use of intravascular chemotherapy and embolisation, especially in the liver prolonged the life of patients with increased life expectation for the cancer sufferers.

Thus, the introduction of CT scanning with early translate and rotate system allowed inaccessible areas to be seen, first starting with the brain in head scan in Singapore installed in 1969 at TTSH and later body studies were enabled with a transaxial CT scans.

MRI was first introduced in Singapore in 1986 with the first Asian installation brought in by an entrepreneur radiologist in private practice. This really altered the scenario and radiology became significantly important with early detection of pathology, especially in bones and the soft tissue structures where abnormality is identified by the difference in contrast seen in the T1, T2 protocols.

These so call double contrast images are far superior in diagnostic value compared to the CT scans without the use of IV contrast enhancement which was forged with serious side effects at that time, before the introduction of non-ionic contrast in the late 1980s. Neurological diseases in the brain and spine benefited most from the MRI studies as these were inaccessible previously without surgical intervention. Surgical intervention for lesions localised by special MRI machine were carried out in Boston's University in the early 1990.

Follow-up studies also was made easier and more accurate with the non-radiation technique.

From the early 1980, Radiology began to command greater awareness with the detection of head and body pathology and the need for open biopsy were significantly reduced.

Since the mid-90s with the latest advances made in MRI scanning, physiological changes can also be evaluated with the functional MRI. Orthopaedic diagnosis with MRI adds value and accuracy especially in joint and soft tissue changes.

The development of CT and ultrasound was temporary held back with rapid advances made in MRI techniques in the years 1986 to 1995.

Ultrasound is a modality to be reckon with in the near future. This non-invasive technique will provide detail and impressive imaging for diagnosis and interventional procedures.

Multislice CT scans from 1993 brought back interest in CT for imaging of the lungs especially in CT survey for lung cancer. Shorter scanning time with CT has an edge over MRI but fast MRI available in the last few years continues to dominate the scene.

Currently multislice CTs from16 to 320 slices appear to be the answer for coronary studies.

MRI remains the hallmark for physiological studies in the circulatory systems and brain.

Technology Advances

Technological advances have provided the Radiologists with the growth engine for the evolution to Clinical Radiology, with constant upgrading and improved sophistication of the various X-ray modalities

Specialised equipments need to be upgraded every few years resulting in the high cost in running an X-ray department but income returns outstrip the investments.

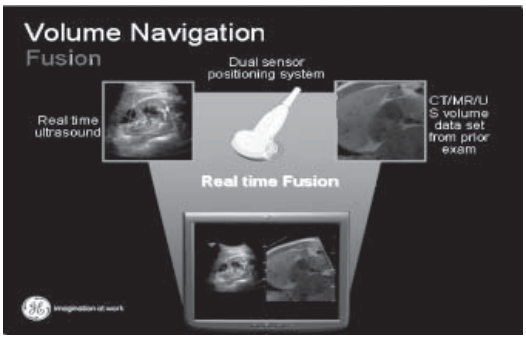
Ultrasound started as a simple machine with the ability to detect the midline shift; evolving to real-time machines which can demonstrate disease of the organs.

As early as the 1980, with the installation of vascular ultrasound for the carotids comes the ultrasound for breast, and now high resolution machines for detailed studies, coupled with colour Doppler display.

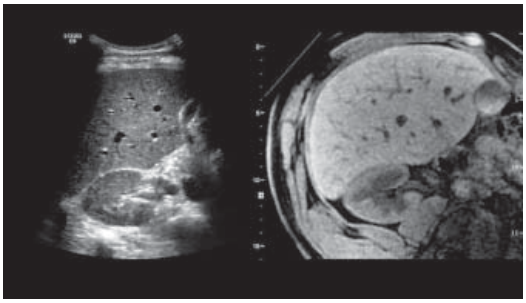
Colour Doppler vascular studies and ultrasound of the skeletal muscular structures offer less expansive non-invasive studies compared to CT and MRI with no irradiation hazards.

In the last couple of years, ultrasound had rapidly gain prominence with its fine resolution real-time imaging. This is still user dependence. Its ability to detect small lesion of less than a cm with added vascular assessment gives

significant advantage. Ablation of isolated tumours of small size is now possible with the latest technology providing more accurate and effective treatment.



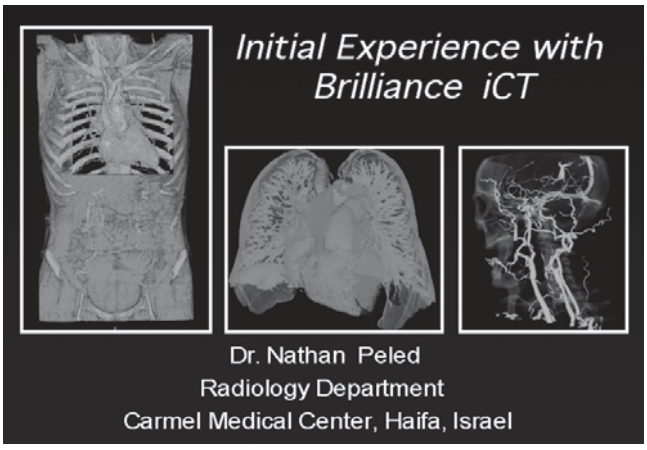
Volume navigation/real time fusion. By Courtesy of Gen Electric.



Fusion U/S examination of Liver cp. to CT scan of liver.

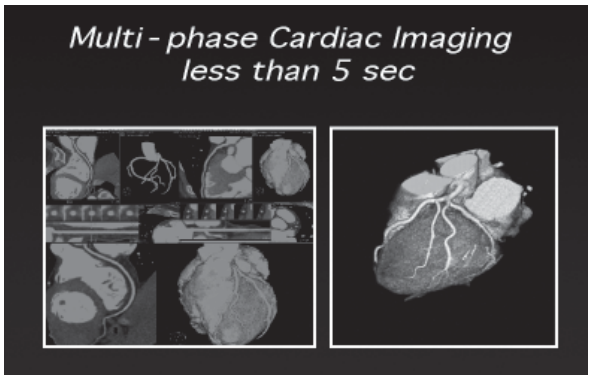
Reduction in radiation dosage with the evolution of the 16th slices to 32 then 64 to 128 and now 360 or more slices machines.

CT scans improved accuracy, and technology advances helped to lower the radiation dosage.



By courtesy of Dr Nathan Peled.

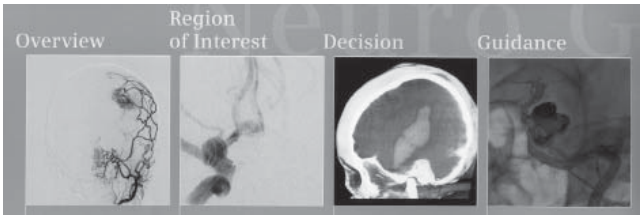
CT has brought about the diagnosis and assessment of coronary artery disease, without the use of cardiac catheterisation and angiogram.



Multiphase coronary angiogram.

More recently, multi-directional CT scanner assists the interventional radiologists and surgeons in their procedures.

Multidirectional CT for interventional procedures.



Preparing for interventional procedures

Modern MRI machines also make tremendous progress and they are becoming less claustrophobic with larger aperture and thinner magnet. Newer protocols may one day elevate the need for contrast enhancement.

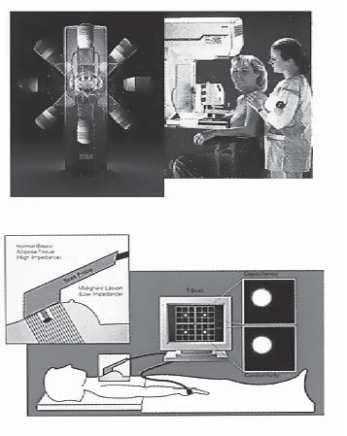
I remember MRI scan in 1986 took nearly ¾ of an hour for a region, be it head, chest and body. Now the faster speed scans allow a whole complete scan to be done in less than 3 min in the 3 Tesla machine.

Today, larger magnets like 3 Tesla nowadays post no problem but allows for the demonstration of very fine pathological details, such as subcentimeter lesion in the

liver. The few 7 Tesla magnets are used mainly for research purpose.

A whole body scan can now be done in three directions on a 3T MRI machine.

Improved mammography techniques and results set the pace for the need to find accurate detection method for the dreaded cancers effecting patients at an early age as early detection could improve the prognosis for the dreaded disease.



Advanced Mammography with Volume imaging.

The advances made in radiology knows no bound, but you and I believe that diagnostic modalities will keep on improving and upgraded and the future for radiology is extremely bright.

Changes in Diagnostic Radiology

The field of radiology and diagnostic imaging has undergone tremendous changes in the last 40 years. All the invasive technologies have been replaced with newer, more accurate and less invasive technologies, e.g. lymphangiogram, the primary imaging modality for evaluating abdominal and pelvic lymph nodes during the time in 1960 plus, has long been abandoned. Besides lymphangiogram, the other studies like pneumoencephalography, hypotonic duodenography, and direct puncture in Carotid and Vertebral angiograms also have gone to the wayside.

Today's Radiology provides for precise imaging techniques with the advanced modalities of ultrasound, CT and MRI creating greater opportunities for interventional procedures, further enhancing our position in medical practice and making the involution to the clinical status complete.

Finally, it is impertinent that I touch on the role of radiologists in the rapid changes made in Diagnostic Radiology.

Radiologists Role

Increased screening will likely lead to increased patient contact as we had seen from screening mammogram experience. With increased patient contact, radiologists must learn how to effectively communicate, not only with our referring physicians but also with patients directly.

The role of radiologists may change from providing disease detection and differential diagnosis to integrating various image findings and putting them in the right context.

The practice of medicine will require a team approach rather than going solo. There is a need to create pathways for general subspecialties and researchers.

The Future

Subspecialisation with continuing research instil in the Radiologist the ability to play a maximum role not only as diagnostician but also as experts in the specialised fields, in the team management of patient care with our clinical colleagues.

All these improvements in modernisation of radiology also help the interventional radiologists in the pursuit of interventional work, in biopsy, and in the treatment of cancers.

Use of fine needle for biopsy can be made more accurately allowing for a localised eradication of the disease and for medications, localised treatment with isotopes and ablation of small tumours.

All these were made possible by continuous advancement in the development of ultrasound, MRI and CT scans.

Credit must be given to the interventional radiologists who with their skills and management have resulted in extension of their ability to treat disease.

More and bigger X-ray departments are being planned and built. It is well known that in planning a department, the architect must cater for expansion of services.

With the rapid expansion of Clinical Radiology, our Radiologists are in great demand and will always be in great demand worldwide. As radiologists we must not be complacent and must always keep up with the advances with ongoing research.

Before concluding, the following will have to be addressed:

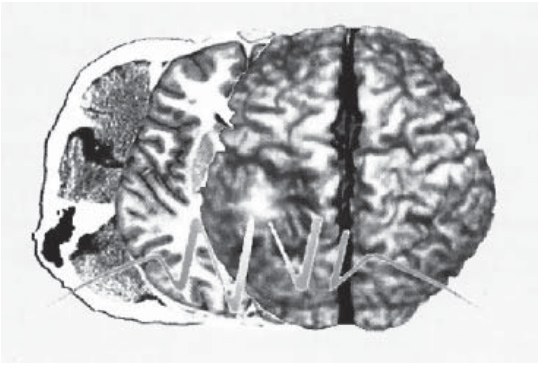
- Procedures like lymphangiogram, air encephalogram and bronchogram have been replaced with CT scanning.

  However in future,
- Would there be a need for contrast enhancement in MRI and CT scan?
- Can CT replace barium meal studies with virtual gastroscopy and colonoscopy?

- Even 20 years ago, it was predicted that contrast would not be needed in MRI studies, we have now seen this in MRI T2 echoes which replaces myelogram and nerve root imaging. MRI flare does away with contrast enhancement for malignant disease.
- Could IVP become absolute?

Radiology has become a complex medical modality

- Radiology trainees have to undergo multiple subspecialisations.
- Is there a need for training in subspecialties?
- Should our trainees go on straight to subspecialisation of the subject that they are interested and proceed to become super subspecialists?



Revolutionary brain waves from radiology.

REFERENCES

1. F Y Khoo: History of Radiology in Singapore 1896-1975. The legacy of Tan Tock Seng Hospital. 140 years of Caring.